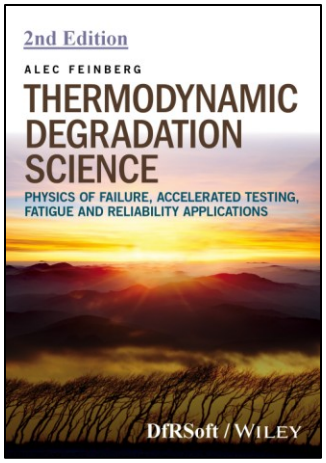
Physics of Failure, Electronic and Mechanical Failure Modes and Models



There are many aspects to the science of physics of failure. In this course we approach the subject by dividing it up into two main sections:

Physics of Failure

- Mechanical Failure Modes & Models
- IC & Electronic Failure Modes & Models

This course is an in depth approach to physics of failure. It is designed for the engineer who wants a good knowledge base including the state-of-the-art in this area.

The following outline provides an overview for each section

1. Physics of Failure Introduction

- Four main types of aging

2. Mechanical Physics of Failure & Material Selection Stress Considerations

- **Elastic deformation, yielding** (with vibration) and ductile rupture (with shock) material considerations
- **Creep & cumulative creep fatigue** material considerations, viscoelastic creep, creep acceleration factor
- **Excessive wear; friction & lubrication** – types of wear, vibration wear, material selection & hardness, wear acceleration factor
- **Cyclic Fatigue:** Exact method for damage estimation (derivation using thermodynamic work)
- **Miner's approximation** – derivation, why it is an approx., stress concentration
- **SN curves – material selection**
- **Fatigue** (SN curves, Basquin's and Coffin-Manson -high and low cyclic fatigue, Loading Types - stress corrections, Facture Mech. Vibration fatigue, when SN Curves not available)
- **PCB fatigue life** - Circuit board component fatigue life model analysis –Steinberg Method (sine and random)
- **Thermal cycle** (strain, fatigue, acceleration factors derivations for Coffin-Manson & Modified, Norris-Landzberg
- **Method of Combing Thermal & Vibration fatigue**

Homework with Solutions

3. Physics of Failure 7 Step Problem Solving

- **Being a detective**

- **Friendly Databases**

4. Physics of Failure Analysis Tools

- **Digital Microscopy**
- **SEM (FE-SEM, EDS)**
- **Focused Ion Beam**
- **Scanning Auger**
- **C-SAM**
- **Real Time Radiology, X-Ray Maps, ○ X-Ray Fluorescence XRF**
- **FTIR, Thermal Imaging**
- **Functional Electrical Test (Curve Trace)**
- **EMI, EMC Testing**

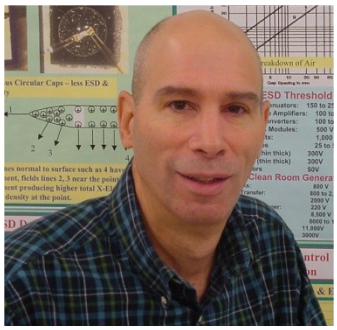
5. Electronic & IC Physics of Failure Considerations

- **Thermal Cycle CTE Stress Issues**
- **CTE's Mismatch, Thermal Fatigue**
- **Engelmaier IPC Solder Joint Life Model, BGAs**
- **Underfill & Modification to Englemaier model**
- **Drop shock & vibration Electronic Failure modes**
- **Temperature: Thermally Activated Failure Modes**
- **Top IC Failure Modes due to Heat, Popcorn Cracking, Voiding Delamination**
- **Junction Temperature Issues & Modeling**
- **Voltage Issues**
- **ESD and EOS – Dielectric Breakdown**
- **Current Density & Fusing of Bond wires and wires**
- **Misc PoF Failure Modes**
- **Design Warnings**
- **Electrolytic Caps**
- **Assembly Errors**
- **IC Failure Modes (Latch up, Gate Sinking, Hot Carrier,…)**
- **Solder Failures (non wetting, grain size, leaching, coverage)**
- **Intermetallics - Au Embrittlement, Purple Plague**
- **Corrosion**
- **Corrosion Requirements**
- **Key Forms of Corrosion (General, Galvanic, stress corroiosn,Cl,)**
- **Moisture & Waterproofing (Conformal Coating, Encapsulation, Super Hydrophobic)**
- **Dendritic Growth, Ag Migration & Electromigration**
- **RoHS Lead Free Solder Issues**
  - **Lead Free Issues: European directive, Pb-Free Failure Modes, SAC Solders**
  - **PCB Copper Dissolution from reflow - Via issues, PCB CTE Z-direction issues**

- **Surface finishes (ENIG,Immersion Silver, Immersion Tin, OSP, Benefits, Issues)**
  - **Tin Whisker**

6. (Special Topics) Cutting Edge Physics of Failure Methods and Models

- **Work Approach to Obtaining a Physics of Failure Aging Law (Example: Creep, Wear)**
- **Using Free Energy Method to Assessing Life (Experimentally and Modeling)**
- **Generate an SN Curve using established rules (including notches, grain size, etc.)**
- **Weibull Beta to obtain physics of failure power aging laws**
- **Subtle Prognostics Using Noise (a subtle way to measure impending failure when obvious signs are not producing results)**
- **1/f Noise in Oscillators and Other Devices - Reliability Considerations**



Dr. Alec Feinberg is the founder of **DfRSoft**. He has a Ph.D. in Physics and is the principal author of the books, Design for Reliability (DfR) and Thermodynamic Degradation Science: Physics of Failure, Accelerated Testing, Fatigue, and Reliability Applications. These books are written in an industrial environment, and are very practical. Alec has a logical approach to the DfR processes using a stage gate method since products are develop in these phases. Alec uses this method in his reliability training classes as well found on the DfRSoft website. Alec is also the principal developer for DfRSoftware which is the most thorough reliability tool currently available and is also used to accelerate learning in his training classes. Alec industrial experience has allowed him to provide extensive reliability engineering services in diverse industries (AT&T Bell Labs, TASC, M/A-COM, Tyco Electronics, and Advanced Energy) for over 35 years on solar, thin film power electronics, defense, microelectronics, aerospace, wireless electronics, and automotive electrical systems. He has provided training classes in Design for Reliability & Quality, Shock and Vibration, HALT, Reliability Growth, and Electrostatic Discharge. Alec has presented numerous technical papers and won the 2003 RAMS Alan O. Plait best tutorial award for the topic, "Thermodynamic Reliability Engineering."

- ***This is a one to two day course depending on special topics and other selected topics from our Modular Courses list ($525-$850)***